Use of a Combination of Anion and Cation Exchange Resins in the Treatment of Edema and Ascites

By B. L. Martz, M.D., K. G. Kohlstaedt, M.D., and O. M. Helmer, Ph.D.

A mixture of a carboxylic acid type of cation exchange resin and a weakly basic anion exchange resin has been used successfully to control the edema of 42 patients with congestive heart failure and the ascites of 14 patients with cirrhosis of the liver. Approximately one-third of the cation exchanger was supplied in the potassium cycle.

Inclusion of the anion exchange resin resulted in a greater sodium uptake per gram of resin and apparently decreased the incidence of disturbances in acid-base balance in patients with impaired renal function who were treated with resins.

Approximately 100 years ago two English agricultural chemists, Thompson and Way, recognized and studied extensively the principle of ion exchange as it applied to soil. They observed that when a water-soluble fertilizer such as ammonium sulfate or carbonate was added to soil, ammonia was retained and an equivalent amount of calcium released by some constituent of the soil. They concluded that aluminum silicates were responsible for this phenomenon. These reports stimulated the interest of other agricultural chemists, but not until the beginning of the twentieth century did the potential importance of ion exchange in industry become apparent. A German chemist, Gans, is credited with providing the impetus for industrial application of ion exchange substances. Subsequent to his report, natural and synthetic silicates found wide use in purification and separation processes.

The versatility of application of the ion exchange principle was greatly increased by the discovery by Adams and Holmes in 1935 that various synthetic resins, chemically similar to Bakelite, possessed ion exchange properties. These investigators demonstrated that certain resins exhibited an affinity for cations, others for anions.

Synthetic resins are polymers of high molecular weight, sufficiently cross-linked to have a negligible solubility. The resin contains many accessible ion exchange groups, amine in the case of anion exchange resins, sulfonic or carboxylic in the case of cation exchangers.

The first application of ion exchange resins in clinical medicine was the employment by Segal in 1945 of a polyamine resin (anion exchanger) to reduce gastric acidity in the treatment of peptic ulcer.

In 1946, William Dock reported animal experiments showing that a synthetic cation exchange resin could be used to take up sodium from the intestinal tract, thus increasing fecal excretion of this element. He reported that 20 to 30 mg. of sodium per gram of resin was taken up when rats were fed 10 to 25 per cent of their diet as resin.

In 1949, Irwin, Berger, Rosenberg, and Jackenthal reported on the effect of the administration of a sulfonic acid type of cation exchanger to human subjects. Marked increases in fecal sodium and potassium with concomitant decreases in urinary excretion of these ions were observed. An increase in ammonia and titratable acid excretion in the urine occurred during resin administration. Carbon dioxide concentration of the serum decreased and chloride concentration increased in their patients. Potassium deficiency was also encountered.

Kahn and Emerson used both the sulfonic and the carboxylic acid type of cation exchange
resin in the treatment of edema. In one patient receiving as much as 100 Gm. of sulfonic acid resin per day, an abrupt fall in serum potassium and calcium occurred after approximately 50 days of therapy. One patient who did not exhibit the usually observed rise in ammonia excretion during resin therapy developed subclinical acidosis. These investigators found that equal parts of potassium and ammonium resin prevented excessive potassium depletion without interfering with sodium removal.

The subject of cation-exchange resins in the management of edema was recently reviewed by Dock and Frank.9

The carboxylic acid type of cation exchange resin was chosen for the studies herewith reported, because in vitro this resin has a greater total capacity and exhibits a greater cation uptake at pH levels encountered in the intestinal tract than the now available sulfonic acid resins.10 Resin in the hydrogen rather than the ammonium cycle was used because of its greater palatability.

METHODS

Patients with a severe grade of chronic congestive heart failure or with cirrhosis of the liver with ascites were selected as subjects for the clinical trial of ion exchange resins. They were hospitalized on a ward organized for metabolic investigation, and sodium and potassium balance studies were conducted. A graduate nutritionist directed preparation and serving of the food. Three day menus were prepared for 0.5, 1.0, and 1.5 Gm. sodium diets. The appropriate menu was then followed during each balance study conducted. Results of the analysis of food from a sample tray were found to vary as much as 15 per cent from the value obtained from food charts, but repeated analyses of the same menu varied within very narrow limits.

Feces were collected for three-day periods at the beginning and end of which carmine dye was administered. Only male patients were used in order to lessen the chance of contamination of feces with urine. Feces were collected directly into 4-liter beakers; single specimens were later combined for analysis of the three-day total. Daily 24-hour urine specimens were collected and analyzed for electrolyte content. Urine was preserved by addition of toluene and by refrigeration. Plasma electrolyte determinations were made, as indicated, at one- to seven-day intervals; a modified Beckman flame photometer was used for sodium and potassium analyses.

The analytic methods employed were as follows: digestion of food and feces, Peters and Van Slyke11; sodium and potassium in urine, Mosher and co-workers12; chloride in plasma, Schales and Schales13; chloride in urine, Harvey14; phosphate in urine and feces, Fiske and Subbarow15; sulfate in urine and feces, Fiske16; carbon dioxide content of serum, Van Slyke, Stadie and Neill17; ammonia in urine, Van Slyke and Cullen18; titratable acid in urine, Henderson and Palmer19; calcium in feces, Hawk, Oser, and Summerson.20

Following periods of observation in the hospital during which the effect of resin on renal and fecal excretion of sodium was investigated, patients received mixtures of resin as outpatients, and determination of sodium, potassium, chloride, and carbon dioxide in blood were made at weekly intervals.

RESULTS

Cation Exchange Resins

Two normal subjects were given the carboxylic acid type of resin in the hydrogen cycle. In one individual receiving 15 Gm. of resin in 200 cc. of water three times daily, the amount of sodium in the feces during three days increased from 16 to 82 mEq. and the potassium content during the same period increased from 18 to 54 mEq. In this subject no change in plasma electrolytes was observed, but, in a second person given 15 Gm. of carboxylic resin four times daily for eight days, serum potassium declined from 4.5 to 2.9 mEq. per liter. Excretion of sodium for three days increased from 8 to 180 mEq. and the potassium excretion increased from 36 to 292 mEq. In both individuals a marked decrease in urinary excretion of sodium and potassium occurred during resin administration.

It was found that the decrease in serum potassium could be avoided by administering tablets of potassium chloride or by providing potassium in the form of the potassium salt of the resin. The latter proved to be preferable as the necessary amount of this cation could thus be supplied without increasing the anion intake.

The potassium salt of the carboxylic acid type of resin was administered to four patients in doses of 30 Gm. per day. This form of the resin was effective in removing sodium from the intestinal tract, as evidenced by a decrease in urinary sodium and an increase in urinary potassium equal to the potassium content of the resin administered. However, sufficiently large
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Diagnosis</th>
<th>Dietary Sodium mEq./day</th>
<th>Resin Dosage H K Anion Gm./day</th>
<th>Fecal Excretion of Sodium mEq./day</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>Per Gm. Resin</td>
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<tr>
<td>Patient 1</td>
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<tr>
<td>Patient 2</td>
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<td>Patient 3</td>
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<td>Patient 5</td>
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<td>Patient 9</td>
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<td>Patient 10</td>
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<td>Patient 11</td>
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<tr>
<td>Patient 12</td>
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<tr>
<td>Normal</td>
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</tbody>
</table>

* Ammonium resin in place of hydrogen.  † Resin administered with meals.
‡ Resin administered between meals.  § Resin suspended in water.  ¶ Resin suspended in milk.
doses to be useful therapeutically could not be given without exceeding the ability of the kidneys to excrete potassium. After approximately two weeks therapy in two of the above patients serum potassium concentration rose to 6 mEq. per liter.

Trial of various proportions of hydrogen and potassium resin revealed that with the mixture of one-third potassium resin and two-thirds hydrogen resin a sufficient amount of potassium was provided to maintain urinary excretion of this ion at approximately the same level as it had been prior to administration of resin. Concentration of potassium in the plasma remained normal.

This mixture of resin was used to control edema in 12 patients with severe congestive heart failure over a period of 2 to 13 months. The sodium excreted in the feces during resin administration varied from patient to patient and varied considerably with the degree of sodium restriction. (See table 1.) In patient 4, on a daily dietary intake of 1 Gm. of sodium, only 0.23 mEq. of sodium was taken up by each gram of resin. In patient 1, receiving approximately 3 Gm. of sodium per day, the resin removed 1.1 mEq. of sodium per gram. Analysis of six three-day stool specimens on four patients receiving a 3 Gm. sodium diet (patients 1, 2, 3, and 6 in table 2) showed an average sodium uptake of 0.96 mEq. per gram of resin.

During administration of resin, sodium excretion in the urine decreased markedly in all patients except those with cirrhosis of the liver in whom renal excretion of sodium had been low prior to resin ingestion. Urinary excretion of chloride remained relatively constant. A marked increase in urinary ammonia and titratable acid occurred on starting resin therapy and was maintained during its administration. In the majority of patients this resin mixture caused only a slight change in the carbon dioxide content of the serum and concentration of chloride in the plasma. However, in three patients with severe impairment of renal function, a marked increase in chloride and a decrease in carbon dioxide content occurred. Figure 1 illustrates the data obtained on such a patient. In this individual, who had congestive heart failure due to arteriosclerotic heart disease and rather markedly impaired renal function (urea clearance 28 per cent of average normal), a progressive lowering of the carbon dioxide content of the serum was observed. When it had decreased to 13.5 mEq., the resin was discontinued and this resulted in a prompt return of the carbon dioxide content to normal. Similar results were noted in two other patients. Substitution of the ammonium salt of the carboxylic acid resin for the hydrogen resin in the amount necessary for equal sodium removal did not decrease the acidotic tendency.

FIG. 1. Acidosis Produced by Cation Exchange Resin. In patient W. S. a lowering of carbon dioxide content occurred during treatment with cation exchange resin which had been started approximately one month prior to the beginning of this graph. When carbon dioxide content had declined to 13.5 mEq., resin was discontinued. Carbon dioxide promptly returned to a slightly elevated level. A second attempt at resin administration also resulted in a decrease in carbon dioxide content. When resin was discontinued a gain in weight promptly occurred necessitating the use of mercurial diuretics.

Use of Anion Resin with the Cation Exchanger

In an attempt to prevent lowering of the serum carbon dioxide content by increasing the fecal excretion of anions, it was decided to observe the effect of the administration of a mixture of the cation exchanger and a weakly basic anion exchange resin. When a mixture containing 12 per cent anion resin, 29 per cent potassium resin and 59 per cent hydrogen resin (Carbo-Resin)* was given to a patient who had developed acidosis on the cation exchange resin alone, the previously noted decline in carbon

* Sodium Removing Resins, Lilly.
shows the effect of resin administration on the fecal excretion of chloride, sulfate, and phosphate. The menu for each patient was duplicated during the three periods of study. Dosage was the same during the two resin periods. The order in which the two types of resin were administered was varied to eliminate such factors as duration of therapy. During the period in which cation exchange resin was being taken, the concentration of anions in the feces declined. The addition of 12 per cent anion exchanger increased anion excretion (primarily phosphate) approximately 25 mEq. per day.

Thus, fecal excretion of anions approached but did not equal the control value. During the same study an inverse change in urinary excretion of phosphate was observed. This is illustrated in figure 3.

Effect on Sodium Uptake. The addition of the anion exchange resin also improved the uptake of sodium by the cation exchanger. In the six patients included in table 3 the fecal excretion of sodium was determined for a three-day period prior to the administration of resin, when cation exchange resin alone was given, and when a mixture of anion and cation resin was given. Each patient’s menu was ex-

Table 2.—Fecal Excretion of Anions
(mEq. per three days)
Patient: C. W. No. 256894 Dietary Sodium: 3 Gm. per day

<table>
<thead>
<tr>
<th></th>
<th>Without Resin</th>
<th>Resin: 60 Gm. per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cation</td>
</tr>
<tr>
<td>Chloride</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Sulfate</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Phosphate</td>
<td>206</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>281</td>
<td>109</td>
</tr>
</tbody>
</table>

Patient: W. S. No. 45875 Dietary Sodium: 1.5 Gm. per day

<table>
<thead>
<tr>
<th></th>
<th>Without Resin</th>
<th>Resin: 51 Gm. per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cation</td>
</tr>
<tr>
<td>Chloride</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Sulfate</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Phosphate</td>
<td>200</td>
<td>98</td>
</tr>
<tr>
<td>Total</td>
<td>213</td>
<td>121</td>
</tr>
</tbody>
</table>

dioxide content did not recur, although no measurable improvement in renal function had taken place (fig. 2).

Effect on Fecal Excretion of Anions. Table 2
actly the same during all periods of study. In every instance the cation-anion mixture caused a greater fecal excretion of sodium even though the actual amount of cation exchange resin administered was less. Fecal excretion of potassium was also greater. The increased efficiency of the mixture was of the greatest amplitude in patients receiving the lower sodium diets. The increase in the sodium removing capacity obtained by adding anion resin to the cation exchanger is also illustrated in figure 4. This patient was in approximate sodium balance on a diet containing 1.5 Gm. of sodium, but when mEq more than had been taken up by the cation exchanger alone. Thus, at this level of sodium intake, a 60 Gm. per day dosage of the cation-anion mixture would remove approximately 0.5 Gm. more sodium than an equal dose of the cation resin.

Effect on Calcium and Iron Metabolism. Frequent determinations of serum calcium, phosphorus, and alkaline phosphatase in patients receiving resin have revealed no significant deviation from normal. Comparative x-ray films before and after six to nine months of resin therapy in several patients have shown no detect-

### Table 3.—Effect of Dietary Sodium on Efficiency of Cation Resin and Cation-Anion Mixture of Resins

<table>
<thead>
<tr>
<th>Patient</th>
<th>Dietary Sodium mEq./day</th>
<th>Resin Dosage Gm./day</th>
<th>Fecal Excretion of Sodium (mEq.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control (No resin)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>per day</td>
</tr>
<tr>
<td>M. W.</td>
<td>41</td>
<td>75</td>
<td>2.6</td>
</tr>
<tr>
<td>W. S.</td>
<td>61</td>
<td>68</td>
<td>3.2</td>
</tr>
<tr>
<td>J. F.</td>
<td>58</td>
<td>60</td>
<td>1.5</td>
</tr>
<tr>
<td>C. W.</td>
<td>113</td>
<td>68</td>
<td>3.9</td>
</tr>
<tr>
<td>E. H.</td>
<td>127</td>
<td>51</td>
<td>2.0</td>
</tr>
<tr>
<td>F. J.</td>
<td>128</td>
<td>60</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Uptake of sodium by resin is considerably greater on the more liberal sodium diets than on diets very low in sodium. In each of the patients listed the sodium removed per gram of resin was greater during administration of the cation-anion mixture than when the cation resin alone was given.

The administration of 60 Gm. of the cation exchange resin resulted in a marked increase in sodium content of the feces as shown in the second portion of the graph. When 8 Gm. of anion exchange resin was added, fecal excretion of sodium increased from 138 to 150 mEq. per day. The marked reduction in urinary excretion of sodium is also illustrated. When the same patient was given a mixture of the ammonium salt of the carboxylic acid resin and potassium resin for a period of two weeks and the balance study repeated, fecal excretion of sodium was only 45.6 mEq. per day. Fecal potassium was also less.

In five patients receiving a 3 Gm. sodium diet and the anion-cation resin mixture (patients 1, 2, 3, 7, and 9, table 1), analysis of 10 feces specimens, each collected over a three-day period, revealed an average sodium uptake of 1.26 mEq. per gram of resin. This was 0.3
able change in the density of the small bones. Studies of the comparative fecal excretion of calcium in seven patients showed an average increase of 9.8 mEq. per day during resin administration.

Determinations of hemoglobin, red cell count and hematocrit on all patients receiving resin for prolonged periods have shown no evidence of anemia. One patient who had an iron deficiency anemia due to bleeding hemmorhoids at the time resin was started and who received simultaneously 0.3 Gm. of ferrous sulfate and 15 Gm. of Carbo-Resin four times daily manifested a normal hematopoietic response. The hemoglobin increased from 48 to 77 per cent; red blood cell count from 3,000,000 to 3,900,000 in one month.

Administration of Mercurial Diuretic during Resin Administration

Resin potentiates the effect of mercurial diuretics in patients with both congestive heart failure and cirrhosis of the liver. As an example, E. H., with severe cirrhosis, excreted 1800 ml. of urine containing 170 mEq. of sodium and 188 mEq. of chloride in the 24 hours after injection of 2 cc. of an organic mercurial compound. Later, at a time when the amount of edema and ascites was approximately the same and the sodium and water intake identical, but when the patient had been receiving a mixture of resins for six days, 3800 ml. of urine containing 330 mEq. of sodium and 400 mEq. of chloride was excreted in the 24 hours after the intramuscular injection of the same dose of mercurial diuretic.

Clinical Application

The mixture of anion-cation resin has been given continuously to 42 patients with congestive heart failure and to 14 patients with ascites due to cirrhosis of the liver for periods of not less than four months. In all but six patients the desired therapeutic effect was obtained. Four of these individuals could not tolerate sufficient quantities of the resin because of gastrointestinal disturbances related to their disease. In two others an exacerbation of pre-existing angina pectoris occurred during administration of resin.

A diet containing 1.5 Gm. of sodium (approximately 3.7 Gm. of sodium chloride) is suitable for starting treatment with resin. This amount of sodium permits the inclusion of most foods of the average American diet in quantities sufficient for adequate caloric intake. Certain foods and seasonings high in sodium must be avoided, and salt cannot be added to the food. The starting dosage of Carbo-Resin is 30 to 60 Gm. per day given in three to six equal parts.

In the average patient this regimen can be expected to produce a negative sodium balance. In the edematous patient, if daily loss of sodium is greater than intake, a decrease in body weight will occur. When the optimum weight is reached, either intake of sodium must be increased or resin dosage reduced. It is possible to deplete the body of sodium by excessive doses of resin or too rigid dietary restriction, producing the so-called "low salt syndrome." When resin is used in conjunction with a very low sodium intake, a greater portion of the cation exchange capacity is utilized in increasing fecal excretion of potassium, and depletion of this ion may be produced.

In patients with a severe grade of sodium retention it is often advisable to give mercury intermittently rather than to use very large doses of resin along with a severe restriction of diet. Relative constancy of sodium intake from day to day is essential for satisfactory control of edema. When marked diet fluctuations occur, resin dosage should be adjusted.

In some patients the use of resin has caused a change in intestinal motility. In a few instances a mild diarrhea has developed, in others, constipation. The latter has been easily controlled by the use of a bulk laxative such as methyl cellulose. No instances of fecal impaction have been encountered.

Two typical examples of the striking improvement observed in this study are contained in the following case reports:

C. W. (No. 256894), a white man, age 35, was known to have had rheumatic heart disease for at least 20 years. The first evidence of congestive heart failure appeared in March of 1949 and was controlled by the usual cardiac regimen. In August, 1950, the patient was admitted to the hospital for a trial on ion exchange resin since a diet of 1.5 Gm. of sodium,
maintenance dosage of digitoxin, and 2 cc. of a mercurial diuretic twice weekly had not controlled his edema. Embolic phenomena made necessary the continuous use of anticoagulant therapy. On a dosage of 60 Gm. of resin per day and a 3 Gm. sodium diet it was possible to maintain the patient free of edema for the subsequent nine months. In May of 1951 resin was discontinued for a period of six days during which there was a gain of 7 pounds in spite of three injections of a mercurial diuretic.

M. W. (No. 261255), a white man, age 68, manifested a marked tendency for ascites formation due to hepatic cirrhosis. Satisfactory control of ascites had been accomplished only by restriction of dietary sodium to 400 mg. per day and administration of a mercurial diuretic three times per week. Attempted lienorenal shunt and portal-caval anastomosis had failed to alter the rate of ascites formation. In the two months following the second operation a total of 64 liters of ascitic fluid had been removed.

Resin administration was started with a dosage of 68 Gm. per day and the dietary sodium was increased to 1 Gm. Abdominal paracentesis was unnecessary for three months. Since release from the hospital the patient's dietary sodium has been increased to approximately 1.5 Gm. necessitating an increase in the resin dosage to 80 Gm. per day. Occasional injection of a mercurial diuretic has been necessary. Liberalization of the protein and caloric content of the diet has resulted in a striking improvement in the patient's nutritional status, and at the present time he is able to do light work.

DISCUSSION

The results presented are interpreted as showing that ion exchange resins afford a practical means of controlling the edema of congestive heart failure and the ascites in many patients with cirrhosis of the liver.

In this study the hydrogen form of the resin has been found to be more palatable, less likely to cause gastrointestinal symptoms, and more efficient by weight than the ammonium salt of the resin. The incidence of acidosis is just as great with the ammonium as with the hydrogen resin, since the ammonium radical is dislodged from the resin in the stomach and converted to urea and is thus not available for combination with anions. Potassium deficiency has been prevented by administering approximately one-third of the cation resin in the potassium form.

The studies presented show that when cation resins and the cation-anion mixture are given in equal doses a greater amount of sodium is removed by the latter in spite of the fact that 12 per cent less cation exchange resin is actually present.

This increase in efficiency of cation resin resulting from the simultaneous administration of anion exchange resin was anticipated on the basis of observations made by industrial chemists. Anion and cation resins are used together in a single deionization column for the removal of electrolytes from water. Use of the mixture results in increased efficiency of both exchangers.

The decrease in acidotic tendency noted with the use of the cation-anion mixture is apparently attributable to the increase in fecal excretion of anions. The anion excretion load of the kidneys is thus lessened. It should be noted, however, that with the mixture used in this study the amount of anion removed in the feces is not equal to the number of cations taken up. In a person with normal renal tubular function, sufficient ammonia is produced to excrete the excess anions and thus prevent significant deviation of the concentration of anions in the blood.

In the treatment of an edematous patient it is important to consider factors other than sodium retention that may contribute to the edema formation. For example, when low serum albumin plays some part in the genesis of ascites or edema formation, removal of sodium by the resins may not completely eliminate the excess fluid from the interstitial space. In fact, as with the use of mercurial diuretics and dietary restriction of sodium, in the presence of hypoproteinemia sufficient sodium may be removed to render the body fluids hypotonic without eliminating the edema. By personal communication two deaths in patients receiving resin have come to our attention. Both had far-advanced liver cirrhosis at the time resin therapy was started; other means of controlling the ascites had failed. Serum albumin in both patients was below the so-called critical level for edema formation. Due to anorexia actual sodium intake was considerably below that prescribed by the physician in charge, and no adjustment had been made in resin dosage. Severe diarrhea was a complication in one of the cases.
Terminally both patients manifested marked sodium deficiency and acidosis.

The average daily dose of Carbo-Resin contains 3 to 4 Gm. of potassium. In patients receiving resin, approximately this amount of potassium is excreted in the urine daily. Obviously in patients in whom oliguria persists after resin therapy has continued for two or three days, there exists the danger of hyperpotassemia.

Long-term studies must be completed before the effect of the continued administration of ion exchange resin on trace elements and the vitamin B complex can be established. No change in the growth curve of rats receiving a diet consisting of 25 per cent cation resin has been observed. No clinical sign of vitamin deficiency or other form of malnutrition has been noted in patients receiving resin for long periods. However, until more evidence is available, a liberal intake of calcium and vitamin B complex is advisable in patients receiving resin continuously for an indefinite time.

In patient 2, table 1, the resin mixture was given with the meals during one three-day period, then between meals during the second period. Fecal analysis revealed no significant difference in sodium uptake.

In some patients, especially children, ingestion of the resin as a suspension in milk rather than water may be preferred. Data on patient 3, table 1, indicate that a slight decrease in sodium uptake probably results from this mode of administration.

Because of their physical characteristics and the relatively bulky dosage, ion exchange resins are not well tolerated by all persons. Further improvement in their form and efficiency is to be expected; this will undoubtedly expand their field of usefulness.

**Summary**

1. A mixture of 12 per cent anion, 29 per cent potassium and 59 per cent hydrogen resin has been administered continuously for periods of not less than four months to 42 patients with congestive heart failure and to 14 patients with ascites due to cirrhosis of the liver.

2. With this mixture it has been possible to control the edema of congestive heart failure and the ascitic fluid accumulation due to cirrhosis of the liver in patients whose response to conventional therapy, including rigid restriction of sodium and frequent injections of mercurial diuretics, had not been satisfactory.

3. The use of presently available resins is contraindicated in persons with severe impairment of renal tubular function unless frequent laboratory determinations are possible.

4. In patients receiving resin, a potentiation of the effect of mercurial diuretics has been observed.

5. By the addition of anion-exchange resin to the cation exchanger it has been possible to increase the sodium-removing capacity of the resin by almost one-third. This addition also decreases the incidence of disturbances in acid-base balance.

**Acknowledgments**

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